THE EFFECTS OF ELECTRICAL SHOCK ON THE ACQUISITION OF A VERBAL EXPECTANCY

By

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CHAPTER I

INTRODUCTION

In recent years Estes (8) and others (1, 2, 3, 20, 23) have reported a number of experiments dealing with the development of a statistical association theory of learning (6, 7, 10). Many of these studies were based on an experimental paradigm originated by Humphreys (16) in which S is asked to predict which of two events will occur on each trial. The occurrence of the events was predetermined according to a random schedule. Thus S was confronted with a problem which virtually precluded mastery. The results of experiments which used this paradigm showed that S characteristically predicted the occurrence of either of the two events about as often as they actually occurred, although such "probability matching" behavior (11) led S to make a considerable number of errors. That is, if one event occurred 10 times, for example, S would predict that it occurred 10 times although not necessarily on those 10 trials on which the event occurred.

Several authors (8, 28) noted that this type of behavior did not maximize the proportion of correct predictions and apparently contradicted the conventional interpretation of the law of effect (24). In their analysis of this situation, these writers assumed that making a correct prediction was more satisfying than making an incorrect prediction and that S should learn to predict the more frequently occurring event on all trials to maximize the number of correct predictions. Hilgard (15), however, suggested that since Ss in these experiments made

their predictions in a no-risk situation, there was not a sufficient difference between the consequences of a correct and an incorrect prediction for the law of effect to apply.

To test the predictions of the statistical association theory against the predictions of the law of effect a situation was designed which provided a sufficient difference between the consequences of a correct and an incorrect prediction by giving S a mild electrical shock whenever he made an incorrect prediction. The statistical association theory says S will predict the occurrence of alternative events about as often as they occur. On the other hand the law of effect predicts that S will learn to maximize the accuracy of his predictions by predicting the more frequently occurring event on all trials. Since the present study differentiated sufficiently between the consequences of a correct and an incorrect prediction, the possibility that S's probability matching behavior was merely an outcome of the particular no-risk situation was tested. The major interest of this experiment was in the difference between the predictions of Ss who received a shock after an incorrect response and the predictions of Ss who were not shocked.

Formal Aspects of the Statistical Association Theory

According to the Estes model (8, 10) it was assumed that on each trial a signal light determined a random set or sample of stimulus elements representative of a population of stimulus elements which were determined by the characteristics of the stimulating situation. The model further assumed that the sample of stimulus elements at any given

time was a constant fraction or proportion of the population of stimulus elements available to S. This constant proportion was called θ, Theta. Estes assumed that the occurrence of either of the two events, called E1 and E2, constituted a reinforcement or a reinforcing event, and that the occurrence of E1 evoked in S a response belonging to the class A1. The response A1 was one which led S to predict the occurrence of E1 and which prevented S from predicting the occurrence of E2 on the next trial. Likewise, it was assumed that the reverse of this process occurred on an E2 trial. That is, the occurrence of E2 evoked in S a response belonging to the class A2, and that A2 was a response which led S to predict the occurrence of E2 and prevented S from predicting the occurrence of E1 on the next trial. Based on the foregoing analysis Estes (8) developed these rules for calculating the change in response probability following an E1 and an E2 trial respectively:

(1) $p(n+1) = (1-\theta)p(n) + \theta$

-or, the probability of A1 on trial n+1 equals the proportion of elements already associated, plus the proportion sampled, and therefore associated, on trial n.

(2) $p(n+1) = (1-\theta)\ p(n)$

-or, the probability of A1 on trial n+1 equals the proportion of elements not sampled times the proportion previously associated.

On the basis of these rules, the following equation was derived to describe the average probability of an A1 response on trial n.

(3) $\bar{p}(n) = \pi - (\pi - \bar{p}(0))\ (1-\theta)^n$

-where π equals the probability of the occurrence of E1, and $1-\pi$ equals the probability of the occurrence of E2, and $\bar{p}(0)$ equals the average probability of an A1 response prior to trial one.

This equation describes a negatively accelerated curve running from the initial value of the probability of an A1 response, $p(0)$, to the asymptotic value, π, as the number of trials becomes large. This equation leads to the prediction that an S will respond so as to match the probability of occurrence of the alternative events. That is, S will predict that an event will occur 15 per cent of the time when that event occurs 15 per cent of the time over an extended series of trials. Predictions generated by equation (3) have been supported by the results of a number of experiments (1, 3, 8, 13, 14, 20).

Review of the Literature on Shock

The use of shock in learning experiments was by no means new, although it had not been applied to the Estes situation before. The results of previous research on the effects of shock on the learning process will be selectively reviewed before considering further details of the present study.

A review article by Rethlingshafer (22) made several points with regard to the use of shock in psychological experiments. She listed five identifiable effects of shock: 1) Emphasizing, 2) Motivating, 3) Disrupting, 4) Alerting, and 5) Informing. She also pointed out that shock may operate in more than one way, in more than one direction, and in an inequal manner from problem to problem. Postman (21) expressed substantially the same view in his review of the role of punishment in

relation to the law of effect. The probable effects of shock may not be stated with any great measure of generality, if these extensive reviews of the literature are used as a guide. Thus certain specific experiments will be cited to illustrate some possible effects of shock as they relate to the present experiment.

Warden and Aylesworth (25) found that rats shocked for a wrong response reached a criterion of nine out of ten correct choices in a discrimination learning problem in 56.2 trials, compared to 293.5 trials required by rats not shocked but given food on a correct choice. In one of a series of experiments on the effects of shock on discrimination learning in the rat, Muenzinger and Fletcher (19) found that both shock-wrong and shock-right conditions led to faster learning than a no-shock procedure. These experimenters concluded that shock after the choice point produced an accelerating factor and that shock before the choice point produced a retarding factor in learning.

Wischner (26) also studied discrimination learning in the rat. He used a noncorrection procedure rather than a correction procedure such as was used by Muenzinger. Wischner's results were similar to Muenzinger's in that shock-wrong conditions led to faster learning than no shock conditions, but showed that shock on a right response led to slower learning than no-shock conditions and had a specific effect with respect to the response punished rather than a general accelerating effect. Woodworth (27) reviewed these and other experiments and suggested that the effects of shock seemed to be to increase vicarious trial and error at the choice point and that VTE seemed to be helpful

to rats in solving discrimination problems.

Estes (5) reported an extensive study of the behavior of rats in a Skinner box with shock used as a punishment. He found that shock depressed the rate of response, but that following the cessation of shock, in their next experimental session, the rats resumed bar-pressing and continued in an extinction series, with the number of trials to extinction dependent on the extent of original training with positive reinforcement. Of particular relevance was Estes' comment that, "The effects of periodically administered punishment are more specific to the punished response." This led to the expectation that S, on receiving shock after a wrong response in the present experiment, would associate the shock with the wrongness of his response and would, presumably, attempt to make as many correct responses as possible.

A study by Freeburne and Schneider (12), on maze learning, was representative of many experiments which used shock as a punishment for wrong responses with human Ss. In this experiment shock was given following a wrong response, following a right response, and following both right and wrong responses to different groups of Ss. The results showed that learning was faster in all three shock groups than in a no-shock control group, that shock-both Ss learned faster than shock-right Ss, and that shock-right and shock-wrong Ss did not differ significantly in rate of learning. The authors noted that their data were consistent with previous research using shock with both human and animal Ss. The findings of this experiment, however, were not in agreement with the earlier results of Muenzinger (18) who found no differences between

no-shock, shock-wrong, and shock-right conditions on a maze learning task using human Ss.

Although shock was used as a consequence of a wrong response in the experiments cited above, these studies may be distinguished from the present study on the basis of the type of learning task involved. In discrimination experiments, S is faced with the task of learning to make correct choices when a correct choice is identified by some discriminable cue stimulus differentiating it from the incorrect choice on every trial. Such is not the case in the Estes-type problem where there is no stimulus associated 100 per cent of the time with a correct choice. Likewise in maze learning experiments, where an incorrect turn at a choice point results in shock, the situation is different from the Estes situation in that S is given repeated runs through the maze until the pattern of right and left turns is mastered and the punishment following an error is avoided. In a random series of alternative events there is no obvious pattern, and S is given only one run through the complete series of trials, which, it is assumed, makes it very difficult for him to learn which alternative will be correct on the next trial.

The Hypothesis Tested

In the light of this review of the use of shock in learning studies, it was expected that shock applied to the Estes-type situation would result in improved learning in Ss who received the shock after an incorrect prediction as compared with Ss who received no shock. That

is, it was assumed that S would learn that shock followed an incorrect prediction and would attempt to avoid shock by making as many correct predictions as possible. To maximize accuracy, Ss shocked after an incorrect prediction would have to make fewer A1 responses than the Ss who were not shocked. Thus shock following an incorrect prediction was expected to result in Ss making fewer A1 responses and therefore fewer errors than Ss who were not shocked.

The following specific hypothesis was tested:

The learning performance of a group of Ss who attempt to predict which of two uncertain alternative events will occur and who receive a mild electrical shock when their prediction is incorrect will be different from the performance of groups of Ss who attempt to make the same predictions but who are not shocked on an incorrect response, when the number of A1 responses and the number of errors are used as an index of learning.

It was predicted that Ss shocked after a wrong response would predict the less frequently occurring event less often than Ss who were not shocked, in accord with predictions derived from the law of effect, and contrary to the predictions derived from the Estes theory.

CHAPTER II

METHOD

Design -- A test of the predictions of the Estes theory and the corresponding opposed predictions of the law of effect had to provide a situation which insured consequences on a correct and an incorrect prediction which were sufficiently differentiating to preclude S being given a no risk choice. The following experimental conditions were designed to satisfy such a requirement:

1. S was required to predict the occurrence of uncertain alternative events over an extended series of trials so that he had an opportunity to determine which of the two events occurred more frequently.
2. The performances of Ss who received shock on an incorrect prediction were compared with the performances of Ss who received no shock.
3. To insure that the differences observed between the no-shock and the shock-wrong groups were produced by the occurrence of shock after an incorrect prediction, there was a third group of Ss which received the same number of shocks on the same trials and at the same point in each trial as the Ss of of the shock-wrong groups. These Ss, however, were shocked whether or not their predictions were correct or incorrect. The performances of these Ss were compared with the performances of the shock-wrong Ss to determine whether the shock

affected S's behavior independently of its following an incorrect prediction.

4. There were three π values, that is the probability of occurrence of the E1 event, used so that the effects of shock in this type of learning situation could be observed over a broad range of π values to test more precisely and efficiently the outcomes predicted by the opposed theoretical views. The use of three π values also permitted further testing of the Estes model under slightly different conditions in a different laboratory.

The three π values used were .05, .15, and .40. These probability values provided for a broad test of the opposed theoretical views. For example, in the case of the .05 groups, if S could learn to predict the more frequently occurring event on all trials, he should have been able to learn in this condition with relative ease. Conversely, in the case of the .40 groups, the task of predicting the more frequently occurring event on every trial was less easy. The .15 groups were included for the purpose of a direct comparison of the results of this experiment with the results of Estes and Straughan (8) to determine whether or not this situation could be said to fit the model it was designed to test, and also to increase the efficiency and generality of the data collected.

In addition to the no-shock and shock-wrong groups, there were noncontingent-shock groups run and the data of the noncontingent-groups were compared with the data of the shock-wrong groups to discover the effects of shock on a wrong response as opposed to the general effects

of shock.

During an initial series of 120 trials the effects of shock given after incorrect predictions as compared with no-shock or noncontingent-shock were evaluated when groups with similar initial response probabilities, that is the Ss in these groups were equally likely to make either an A1 or an A2 response, were given different reinforcement schedules. In a second series of 80 trials, the effects of shock were evaluated when groups with different initial response probabilities were given identical reinforcement schedules.

To control for chance peculiarities of any given event schedule, five different schedules were drawn from a table of random numbers for each of the three initial probability values, .05, .15, and .40 and for the one final probability value, .20. These sets of event schedules were assigned to successive Ss so that every event schedule for a given initial probability value was assigned to two Ss in each group of 10. For one of these pairs of Ss receiving the same schedule, E1 was on the right, and for the other, E1 was on the left. This counterbalancing procedure controlled for S's position preference. A summary of the assignment of experimental conditions to the different groups of the experiment appears in Table 1.

Apparatus -- The data were collected in an 8 x 8 ft. three-sided screened-in booth made of black curtains. A 30 in. square stimulus panel was placed at the closed end of the booth. The panel contained three milk-glass lights; a circular signal light 2 in. in diameter, centered in the panel 18 inches above its base, and two 2 in. square event lights,

TABLE 1

Assignment of Experimental Conditions to Groups of Ss

Group	Experimental Conditions	N	π, Series 1	π, Series 2
1	No-Shock	10	.05	.20
2	Shock-Wrong	10	.05	.20
3	Noncontingent-Shock	10	.05	.20
4	No-Shock	10	.15	.20
5	Shock-Wrong	10	.15	.20
6	Noncontingent-Shock	10	.15	.20
7	No-Shock	10	.40	.20
8	Shock-Wrong	10	.40	.20

each 7 1/2 in. from the center of the panel on both sides of the signal light and 12 in. above the base. A two-way, spring-loaded switch was mounted in the panel 12 in. below the center light. The stimulus panel was painted flat black and was mounted on a base stand which extended 10 in. out from the front of the panel. A 4 in. square was outlined in white on the base stand, centered below the switch. The panel was placed on a 24 in. x 36 in., 30 in. high table. S sat on a chair 21 in. high facing the panel, surrounded by the three-sided experimental booth. Figure 7 in the Appendix contains a photograph of the stimulus panel. Windows of the experimental room were covered with black curtains which blocked out most extraneous light from the booth. During

an experimental session, the booth was lighted by a 40 watt bulb hung approximately above S's left shoulder as he sat facing the stimulus panel.

The lights in the stimulus panel were operated manually by E, who was seated at a control switch board at the right rear outside edge of the experimental booth. A wiring circuit permitted E to initiate each trial by turning on the circular signal light in the center of the panel. When S made a prediction by pressing the panel switch either to the right or left, his response turned off the center light and turned on whichever of the two square-shaped side lights E had predetermined was correct on any given trial. As required, a light flashed in E's control switch board to signal E that the prediction was incorrect. The onset of the center light and the operation of the panel switch by S activated appropriate signal markers on a Gerbrands four-pen recorder and provided a continuous record of S's reaction latency and his responses throughout the experimental session. Duration of the event light was controlled by a Model TD, 105-130 volt, 60 cycle interval timer made by the Industrial Timer Corporation, Newark, N. J.

The shock stimulus was a .5 millisecond pulse of about 91 volts which E administered manually by means of a microswitch at the control switch board. A Stoelting No. 58020, 115 volt, 50-60 cycle Electronic Stimulator was used to generate the shock. The intensity of the shock was determined by a preliminary study using two male and two female Ss. In the preliminary study, the shock was presented according to a modified method of limits to determine the value of the absolute threshold

and the upper threshold, defined by the instruction given the four Ss as follows: "Now I want you to tell me when the shock becomes so strong you want me not to turn it up any further." There were 10 ascending and 10 descending series in setting the absolute threshold and 10 ascending series in setting the upper threshold. When these thresholds were determined, the intensity of the shock to be used was fixed arbitrarily as the 50 per cent point between the two thresholds. After the intensity of the shock stimulus was set, it was not changed throughout the remainder of the experiment.

Subjects -- The Ss were 80 college students who volunteered to serve as subjects. They were solicited from the beginning Psychology courses at the University of Florida, and most of them received credit towards fulfillment of a course requirement for serving in this experiment. They were advised of the possibility of their being shocked. It was assumed that these Ss were representative of the undergraduate psychology students at the University of Florida who wished to serve in an experiment and who were not discouraged by the possibility of being shocked. The Ss were taken as they reported to the experimental room and were formed into groups of 10 in the following order: Ss 1-10, π = .05 no-shock; Ss 11-20, π = .15 no-shock; Ss 21-30, π = .40 no-shock; Ss 31-40, π = .05 shock-wrong; Ss 41-50, π = .15 shock-wrong; Ss 51-60, π = .40 shock-wrong; Ss 61-70, π = .05, noncontingent-shock; Ss 71-80, π = .15 noncontingent-shock. This schedule was used to avoid the uncontrolled effects which might have resulted from an S previously run telling an S to be run about his experience in the experiment. Such

an effect would have been particularly damaging if Ss who had received shock told Ss to be run but who were not to be shocked about their experiences. Thus, using the schedule outlined above, when an experimental condition was changed, it was E who determined what the change was to be and when it was to be made.

The records of six Ss were eliminated as a result of procedural errors and breakdown of the apparatus. An additional 21 Ss were run in the π = .05, .15, and .40 shock-wrong conditions but were eliminated when it was discovered that the shock equipment, which had been wired to operate automatically, was actuating at times other than on a wrong prediction by S. These 21 Ss were replaced by Ss who were run following a modification of the apparatus which eliminated the possibility of any extraneous shock. The apparatus as it was used throughout the experiment was described in the preceding section. The data of these 21 Ss are shown in Table 2 in the Appendix to complete the record of all Ss run in this experiment. No analysis of these data was attempted as interpretation of the results would be difficult because the data were contaminated by the uncontrolled extraneous shock.

Two other Ss were replaced, one in each of the π = .05 and .15 no-shock groups, because they both questioned E about the possibility of their being shocked upon arriving at the experimental room, because they told E that they did not want to be shocked, and because they were the only Ss in any of the no-shock groups who mentioned shock prior to

being informed whether or not they were to be shocked.[1]

Procedure -- At the beginning of an experimental session S was seated in front of the stimulus panel and was asked to read the following instructions, typed on a 5 x 8 in. card:

"Your job in this experiment will be to predict correctly as often as you can which of the two square-shaped side lights, the right or the left, will light up after the round center light goes off. What you do is wait for the center light to come on, signaling you to make your decision, then press the lever to the right, if you predict that the right light will come on, or to the left, if you predict that the left light will come on. If you cannot decide which of the two side lights will light up, then you may guess.

"You are to make your prediction as soon as possible after the center signal light comes on. Since either the right or the left light will light up on each trial, it will be necessary for you to make a prediction on each trial. After you have made your decision, place your hand on the square outlined on the base of the apparatus and wait for the signal beginning the next trial.

"The way the apparatus is hooked up the experimenter will turn on the center light, and when you make your prediction, the center

---

[1]A record of the Al responses and errors for blocks of 20 trials throughout the experiment of the two original Ss, the two replacement Ss, and the mean scores of the other nine original Ss in both groups appears in Table 3 in the Appendix. The data reported in the main experiment include the two replacement Ss. The analyses of Al response data were made with both the original and the replacement Ss included.

light will go off and the correct side light will come on. This way you will be able to tell if your prediction was correct or incorrect as soon as you make your decision. Remember, your job is to make as many correct predictions as you can."

If S asked questions about the experimental procedure, E answered them by paraphrasing appropriate sections of the original instructions. Other questions were evaded and E asked S to do as well as he could. If S was to be in one of the shock-wrong groups, E asked if S were right or left handed. Then E said, "According to my schedule, you are one of the subjects in this experiment who is to be shocked. I'd like to attach these shock electrodes to your left (or right) thumb." The shock electrodes were then attached to the nonpreferred hand in every case. The two electrodes were taped to the palmar surface of the thumb, opposite the cuticle and at the bend of the first joint. Then E said, "Now we'll try four practice trials." If S was to be shocked, E added, "There will be no shock on these practice trials."

The practice trials consisted of the appearance of the reinforcing event on the left, right, right, and left in that order, regardless of whether El was to be on the right or left during the regular experimental run which followed. After completing the practice trials, E corrected S's procedural mistakes if there were any. Then the experimental booth was darkened, except for the single light bulb above S's left shoulder, and the main part of the experiment was begun. The 200-trial sequence was run off without interruption and with no gap between Series 1 and Series 2.

On each trial the round signal light in the center of the panel came on and remained on until S indicated his prediction by moving the lever to the right or left. S's response turned off the signal light and turned on whichever of the event lights was correct for that trial. If S was in one of the shock groups his response also operated a light in E's control switchboard when the prediction was incorrect. When shock was administered on an incorrect prediction, E operated the microswitch immediately following S's response. The event light remained on for about 1.5 seconds. The intertrial interval was approximately five seconds. The 200-trial sequence was run off at a relatively constant rate and took about 30 minutes for each S.

CHAPTER III

RESULTS

Analysis of A1 Response Data

The three no-shock groups were used as control groups to test the predictions of the Estes theory against the performances of the shock-wrong groups. To test the model fairly, the asymptotic probability of an A1 response in these no-shock groups should have been .05, .15, and .40 in Series 1 and .20 in Series 2. Estimates of the asymptotic probability of an A1 response in the no-shock groups were obtained by taking the number of A1 responses made by each S on the last 20 trials of both series, summing over Ss, dividing by 10 to obtain an average for the group, and dividing by 20 to obtain the relative frequency. The asymptotic probabilities of an A1 response over the last 20 trials of Series 1 were .055, .160, and .375, for the π = .05, .15, and .40 groups respectively. The asymptotic probabilities of an A1 response over the last 20 trials of Series 2 were .205, .155, and .310 for the π = .05, .15, and .40 groups respectively. The observed asymptotic probability values of Series 1 were in closer agreement with predictions of the Estes theory than the observed values of Series 2. However, the performances of the three no-shock groups were taken as representative of the Estes model, and were used as a basis for testing the effects of shock on the number of A1 responses made during both Series 1 and 2.

Curves representing the group mean probability of an A1 response for the π = .05, .15, and .40 no-shock and shock-wrong, and for the π = .15 and .15 noncontingent groups for blocks of 20 trials during Series 1 and 2 are shown below in Figures 1, 2, and 3. These curves show the over-all performances and the differences between the performances of the no-shock, shock-wrong, and noncontingent-shock groups for each of the three π values.

To determine whether the over-all differences between the performances of the no-shock and shock-wrong groups were significant, the A1 response data of the three pairs of no-shock and shock-wrong groups for trials 1 through 200 were analyzed by means of a Mixed Model, Type 1 analysis of variance, as outlined by Lindquist (17). The difference between the π = .05 no-shock and shock-wrong groups was significant, $F = 6.37$, $.05 > p > .01$. The differences between the π = .15 and .40 no-shock and shock-wrong groups were not significant, $F = 2.18$, and $F = 0.06$ respectively. Summaries of these analyses are shown in Tables 4, 5, and 6 in the Appendix. These analyses indicated that there was a significant difference between the over-all performances of the π = .05 no-shock and shock-wrong groups, that although the difference between the π = .15 no-shock and shock-wrong groups was consistent, it was not significant, and that the difference between the π = .40 no-shock and shock-wrong groups was negligible.

To evaluate the differences between the no-shock and shock-wrong groups with regard to asymptotic learning performance, the number of A1 responses over the last 20 trials of Series 1 and 2 were analyzed by a

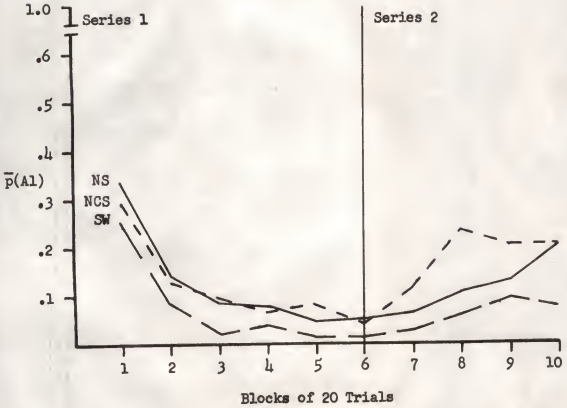


Fig. 1. Group mean probability of an A1 response for $\bar{w}$ = .05 no-shock (NS), shock-wrong (SW), and noncontingent-shock (NCS) groups for blocks of 20 trials during Series 1 and 2.

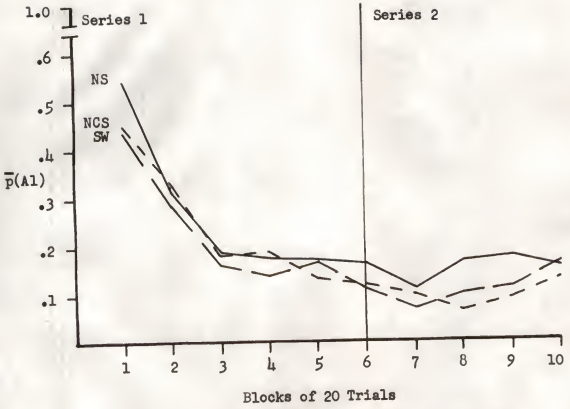


Fig. 2. Group mean probability of an A1 response for $\bar{\pi}$ = .15 no-shock (NS), shock-wrong (SW), and noncontingent-shock (NCS) groups for blocks of 20 trials during Series 1 and 2.

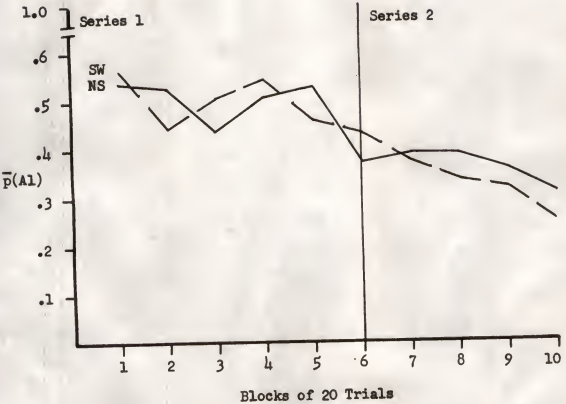


Fig. 3. Group mean probability of an A1 response for $\bar{\pi}$ = .40 no-shock (NS) and shock-wrong (SW) groups for blocks of 20 trials during Series 1 and 2.

series of *t* tests. Tables 7 and 8 contain the mean number of A1 responses, the appropriate variance estimates for the last 20 trials of Series 1 and 2, and the results of the *t* tests of the difference between the means of the three pairs of no-shock and shock-wrong groups. These tables show that in the case of the last 20 trials of Series 2 there was a significant difference between the means of the π = .05 no-shock and shock-wrong groups, *t* = 2.43, .05>p>.01. No other differences between means of the no-shock and shock-wrong groups were significant. In general, this indicated that there were no differences between no-shock and shock-wrong groups on the last 20 trials of Series 1 and 2. That is, the no-shock and shock-wrong groups generally approached the same final level of responding.

In view of the prediction of the Estes theory that groups exposed to the same probability schedules should reach the same final response probability, regardless of their initial tendencies, it was relevant to test this prediction. The test was accomplished by means of an analysis of variance of the A1 response data for the last 20 trials of Series 2. In this analysis the effect of π value during Series 1 was significant, *F* = 8.03, .01>p>.001. The effect of shock and the interaction of shock and initial π value were not significant, *F* = 3.47, and F = 1.44 respectively. The fact that the shock and the interaction effects were not significant required that interpretation of the significant difference between the π = .05 no-shock and shock-wrong groups for the last 20 trials of Series 2, cited above, be limited because of the increased possibility of a Type 1 error when *t* tests are

run after an F test showed that the effect was not significant. A summary of this analysis is shown in Table 9 in the Appendix.

Analysis of Error Data

Estes (9) has shown that the expected percentage of error when S responds in accord with the predictions of the model may be calculated as follows:

(4) Percentage of Errors = 100 - (n(A1) x π - n(A2) x (1 - π))

-or, the percentage of errors expected equals 100 minus the number of A1 responses times the value of π plus the number of A2 responses times the value of 1 minus the value of π.

Equation (4) was used to calculate the theoretical percentage of errors for the three π values of Series 1 and the one π value of Series 2. For the π = .05, .15, and .40 no-shock groups the predicted percentages of errors for Series 1 were 7.25, 25.5, and 48.0 respectively. The observed percentages of the π = .05, .15, and .40 groups during Series 1 were 10.5, 29.5, and 47.0 respectively. The predicted percentages of errors for all groups during Series 2 was 32.0 for all groups. The observed percentages for the initial π = .05, .15, and .40 groups were 39.5, 30.5, and 42.5 respectively. The agreement between observed and theoretical percentages was closer in Series 1 than in Series 2. However, the performances of the three no-shock groups were taken as representative of the outcomes predicted by the Estes theory and were used as a basis for comparison with the data of the shock-wrong groups to test the effects of shock on an incorrect prediction on the number of errors made during Series 1 and 2. The general agreement of the data

of the no-shock groups with the predictions of the Estes theory indicated that the Ss in these groups did not make predictions according to some method which permitted them to satisfy the equations for predicting the final levels of A1 responding while at the same time making an unusually large or small number of errors.

Curves representing the mean percentage of errors for the π = .05, .15, and .40 no-shock, shock-wrong, and for the π = .05 and .15 groups, the noncontingent shock-groups for blocks of 20 trials during Series 1 and 2 are shown in Figures 4, 5, and 6. These curves show the over-all performances and the differences between the performances of the no-shock, shock-wrong, and noncontingent-shock groups for each of the π values.

To determine whether the over-all differences between the performances of the no-shock and shock-wrong groups were significant, the error data for trials 1 through 200 of the three pairs of no-shock and shock-wrong groups were analyzed by means of a Mixed Model, Type 1 analysis of variance as was used to analyze the over-all differences of the A1 response data above. The difference between the π = .05 no-shock and shock-wrong groups was significant, $F = 8.54$, $.01 > p > .001$. The differences between the π = .15 and .40 no-shock and shock-wrong groups were not significant, $F = 4.15$ and $F = 0.04$ respectively. Summaries of these analyses are shown in Tables 10, 11, and 12 in the Appendix. These analyses indicated that there was a significant difference between the π = .05 no-shock and shock-wrong groups, that the difference between the π = .15 no-shock and shock-wrong groups approached

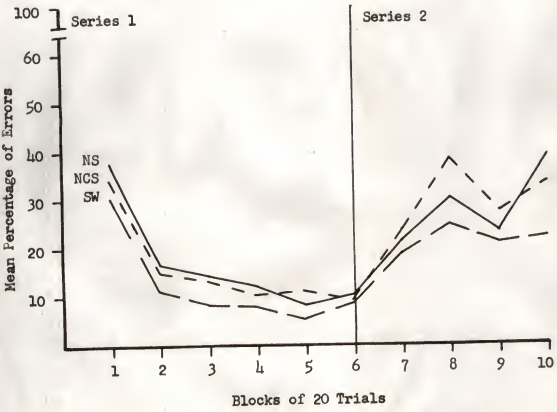


Fig. 4. Group mean percentage of errors for $\bar{\pi} = .05$ no-shock (NS), shock-wrong (SW), and noncontingent-shock (NCS) groups for blocks of 20 trials during Series 1 and 2.

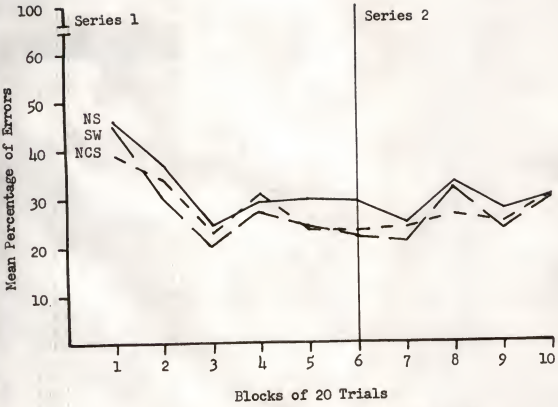


Fig. 5. Group mean percentage of errors for $\bar{\pi}$ = .15 no-shock (NS), shock-wrong (SW), and noncontingent-shock (NCS) groups for blocks of 20 trials during Series 1 and 2.

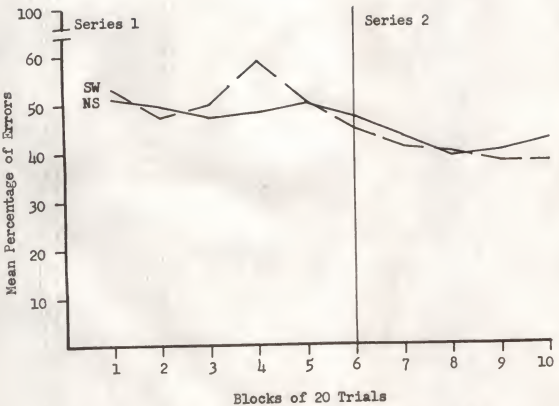


Fig. 6. Group mean percentage of errors for $\bar{\pi}$ = .40 no-shock (NS) and shock-wrong (SW) groups for blocks of 20 trials during Series 1 and 2.

significance, and that the difference between the π = .40 no-shock and shock-wrong groups was negligible.

To evaluate the differences between no-shock and shock-wrong groups with regard to asymptotic percentages of errors, the number of errors made over the last 20 trials of Series 1 and 2 were analyzed by a series of *t* tests. Tables 13 and 14 in the Appendix contain the mean number of errors, the appropriate variance estimates for the last 20 trials of Series 1 and 2, and the results of the *t* tests of the differences between the means of the three pairs of no-shock and shock-wrong groups. These tables show that in the case of the π = .05 no-shock and shock-wrong groups on the last 20 trials of Series 2, there was a significant difference between mean error scores, *t* = 2.12, .05 > p > .01. No other differences between means of no-shock and shock-wrong groups were significant. Generally, these *t* tests showed that shock after an incorrect prediction did not result in shocked *Ss* making fewer errors on the last 20 trials of Series 1 and 2 than *Ss* who were not shocked.

To test the prediction of the Estes theory that groups which receive the same probability schedules will make equal error scores after a number of trials, regardless of their initial response tendencies, the error data were analyzed for the last 20 trials of Series 2. An analysis of variance of these error data revealed that there was a significant effect of initial π value, *F* = 3.63, .05 > p > .01, and that the effects of shock and the interaction of shock and initial π value were not significant, *F* = 3.36, and *F* = 1.19 respectively. The fact that the

shock and the interaction effects were not significant required that the interpretation of the significant difference between the $\pi = .05$ no-shock and shock-wrong groups for the last 20 trials of Series 2, cited above, be limited because of the increased possibility of a Type 1 error when *t* tests are run after an *F* test showed that the effect was not significant. A summary of this analysis is shown in Table 15 in the Appendix. It was noted that the analysis of error data paralleled the analysis of the A1 response data in all respects.

Analysis of the Data of the Noncontingent-Shock Groups

To determine whether the effects of shock were dependent on the shock following an incorrect prediction, the data of the two noncontingent-shock groups were compared with the data of the shock-wrong groups. A summary of the analysis of over-all differences between the $\pi = .05$ and .15 shock-wrong and noncontingent-shock groups appears in Tables 16 and 17 in the Appendix. These tables show that there was a significant difference between the $\pi = .05$ shock-wrong and noncontingent shock groups, $F = 11.15$, $.01 > p > .001$, and that the difference between the $\pi = .15$ groups was not significant, $F = 0.03$. The results of these analyses paralleled the analyses of the no-shock and shock-wrong groups and indicated that the noncontingent-shock groups for $\pi = .05$ gave a performance more like the no-shock than the shock-wrong group.

A comparison of the shock-wrong and noncontingent-shock group data of the last 20 trials of Series 1 and 2 was made by means of a series of *t* tests of the differences between mean number of errors and

Al responses. The results of these t tests are shown in Table 18 in the Appendix. This table reveals that there was a significant difference between the mean number of Al responses and errors for the π = .05 shock-wrong and noncontingent-shock groups on the last 20 trials of Series 2, t = 3.47, .01 > p > .001 for Al responses and t = 3.66, .01 > p > .001 for errors. The differences between the π = .15 shock-wrong and noncontingent-shock groups were not significant. The differences obtained in the case of the π = .05 groups on the last 20 trials of Series 2 paralleled the differences found between the no-shock and shock-wrong groups and indicated that the noncontingent-shock group gave a performance more like the no-shock than the shock-wrong group.

The results of the analyses of the noncontingent-shock data generally showed that the differences between no-shock and shock-wrong groups, where such differences were observed, were the result of the contingency of shock on an incorrect prediction and were not produced by the nonspecific effect of shock alone.

Analysis of the Reaction Latency Data

The apparatus recorded the onset of the signal light, and S's response turned off the light. Thus it was possible to measure the length of the time the signal was on, or the time it took S to react to the signal light. Although the statistical association theory did not provide for specific predictions with regard to reaction latency in this experimental situation, the latency data were studied to shed more light on the differences found between the various no-shock and shock-wrong groups. Tables 19 and 20 in the Appendix contain the results of

the t tests of the differences between the mean reaction latencies of the no-shock, shock-wrong, and noncontingent-shock groups on the final trials of Series 1 and 2. The reaction latency for each S was estimated from his mean latency on the last 10 trials of both series. The tables show that there were no significant differences between the means of the no-shock and shock-wrong groups, and no differences between the means of the shock-wrong and noncontingent-shock groups.

In addition to the analysis of the latency data presented above, the latency of each S on his last A1 response of Series 1 and the latency on his A2 responses immediately preceding the last A1 response were measured. These data were summed and averaged so as to provide a group mean latency for the final A1 response and the A2 response immediately preceding it based on the 10 Ss in each of the eight groups of the experiment. The differences between the mean reaction latency of the A1 and the A2 response were tested by means of a series of t tests. A summary of these t tests appears in Table 21 in the Appendix. This table shows that there were no significant differences between the mean reaction latency on the last A1 response of Series 1 as compared with the latency on the A2 response immediately preceding it. It was hypothesized that the Ss would learn that the E1 event occurred less often than the E2 event, and that they would be more likely to make an error when they predicted an E1 event by making an A1 response. Thus it was expected that there would be a significant difference between the mean reaction latency on an A1 as compared with an A2 response in the shock-wrong but not in the no-shock groups. It was expected that this difference, if

observed, would occur in Series 1 while all groups were receiving different probability schedules. This hypothesis was rejected on the basis of the gross analysis of the mean reaction latencies and the analysis of the mean reaction latencies on the final A1 response and the A2 response which immediately preceded it.

Summary of the Analysis of All Data

Analysis of the A1 response and error data gathered in this experiment showed that in general the effects of shock after an incorrect prediction resulted in significant differences in the case of the π = .05 no-shock and shock-wrong groups, but not in the case of the π = .15 no-shock and shock-wrong groups, where there were small and consistent differences, nor in the case of the π = .40 no-shock and shock-wrong groups, where the differences were negligible. The analysis of the data of the last 20 trials of Series 1 and 2 showed that only in the case of the π = .05 no-shock and shock-wrong groups for the last 20 trials of Series 2 were there significant differences and these had to be cautiously interpreted as noted above. The analysis of the data of the noncontingent-shock groups showed that the effects of shock after an incorrect prediction, where observed, were the result of the contingency of the shock on an incorrect prediction and not the general effects of shock alone. The analysis of the reaction latency data showed that there were no significant differences between no-shock and shock-wrong groups with regard to reaction time.

CHAPTER IV

DISCUSSION

The most striking finding of this experiment was the effect of shock on a wrong response as revealed in the analysis of variance of the over-all performances of the groups given the different probability schedules. It was expected that shock would result in the Ss making their predictions so as to avoid the possibility of shock as much as possible. To do this they would have had to predict the more frequently occurring event on all trials. Instead of doing this, many Ss continued to predict the less frequently occurring event from time to time, in spite of shock after an incorrect prediction.

In considering various possibilities to account for this result it was seen in Figures 1, 2, and 3 that the curves of the π = .05 and .15 shock-wrong groups for the first 20 trials were below the no-shock curves. This suggested that the differences between the pairs of no-shock and shock-wrong groups might have existed prior to the start of the experiment due to sampling biases. To check this possibility the number of A1 responses made by Ss in all groups on the four practice trials and the first trial of the main experimental run, or, all trials before any S received a shock, were compared by means of a series of t tests. Table 22 in the Appendix contains the results of these t tests and shows that there were no significant differences in number of A1 responses before the first shock was given. Thus it was concluded that the initial response tendencies of the groups of Ss in this experiment

were not unequal due to sampling biases.

Other possible sources of bias were also considered. Position preference was controlled by counterbalancing the position of E1 and E2. The peculiarities of any one event schedule were controlled by using five different event schedules within each probability group. And the possible effects of intercommunication among Ss already run and Ss to-be-run were controlled by the order of running the various groups. The instructions given S did not suggest that he could not adopt any method of responding which insured that he would make as many correct predictions as possible.

Mention of the assumptions of the subject as he came to the experimental room to serve in this study brings up an important point. Disregarding the effect of shock momentarily, the general attitudes of S will be considered. It was expected that S would read the instructions and then try to make as many correct predictions as possible. It was expected that Ss who received shock would learn to maximize the accuracy of their predictions. It was not expected that S would master the task, which in fact had been devised to prevent mastery. However, if S interpreted his instructions as meaning that he should learn to make 100 per cent correct predictions, it is likely that he would have kept trying to out-guess the random sequence although the less frequently occurring event seldom occurred and the likelihood of error associated with its prediction was great. If S was trying to master the problem, and the comments of many Ss indicated that this was the case, then the data of this experiment may be viewed as the outcome of

Ss trying but failing to master a difficult problem. This view of the data is not that taken by the Estes theory, which holds that the probability matching law describes an automatic or unconditioned type of associative learning phenomenon.

Now, supposing that the above analysis of S's attitude is correct and that he interpreted the instructions to mean that he must learn to predict correctly 100 per cent of the time, what effects would the various probability schedules have had on his behavior, particularly with respect to errors since it was reasonable to assume that if S tried to be correct he also tried to avoid errors?

Probably the Ss given the π = .40 schedules found it difficult to disregard the events occurring less frequently on one side in favor of predicting the more frequently occurring events on all trials. To do so would involve acceptance of a considerable number of errors, and it was assumed that an S trying to attain 100 per cent accuracy would not be able to disregard 40 per cent errors and predict the more frequently occurring event on all trials.

In the case of the Ss given the π = .15 schedules it might have been possible to disregard the less frequently occurring events on one side by concentrating on the more frequently occurring events on the other side. In such a case 100 per cent mastery could be approached, but not very closely.

For the Ss given the π = .05 schedules, according to the hypothesis developed here, it should have been much easier to disregard the less frequently occurring events on one side in favor of the near-

perfect accuracy yielded by predicting the more frequently occurring event on all trials. These Ss were not constantly reminded that they were not predicting correctly 100 per cent of the time when they predicted the more frequently occurring event on all trials.

Thus far it has been suggested that S was trying to achieve mastery of the problem given him and that in view of this attitude he would be less likely to predict the more frequently occurring event on all trials the nearer the probability of occurrence of that event approached .50. Expressed differently this hypothesis would say that Ss predicting the occurrence of uncertain events would reach a level of responding which depended on the number of errors resulting from the behavior that they adopted.

This hypothesis was the result of a trial-by-trial study of the records of all Ss who predicted the occurrence of the more frequently occurring event on all of the last 20 trials of Series 1. These records showed that the Ss may have learned not to react to the less frequently occurring event because the number of errors resulting from predicting the more frequently occurring event on all trials did not involve making more errors than they could disregard in their attempt to achieve 100 per cent accuracy.

As was expected on the basis of the above discussion, there were more Ss in the three $\pi = .05$ groups (18) than in the other groups who predicted the more frequently occurring event on all of the last 20 trials of Series 1. These Ss made fewer A1 responses during Series 2 than the other Ss in their respective groups, indicating that the learn-

ing transferred when the probability schedule changed. There were four Ss in the π = .15 groups who predicted the more frequently occurring event on all of the last 20 trials of Series 1. These Ss all made fewer A1 responses during Series 2 when the probability schedule changed than the other Ss of their respective groups. This outcome would have been expected according to the hypothesis suggested above. None of the Ss in the π = .40 groups predicted the more frequently occurring event on all of the 20 trials of Series 1, a result also in accord with the foregoing analysis.

Turning now to the differences between groups as a result of shock on an incorrect response, the data suggest that shock had the effect of decreasing Ss attempt to attain 100 per cent mastery of the problem. This was not a simple and direct effect, however, but on the other hand it interacted with Ss attempt to attain mastery. That is, the effect of shock was different for the different probability schedules used. The data indicated that the general over-all effect of shock was significant in the case of the π = .05 groups. These groups received the probability schedules which the above hypothesis predicted would lead to Ss predicting the more frequently occurring event with least difficulty. Thus, where S was most likely to predict the more frequently occurring event on all trials, shock was seen as having the greatest effect. That is, if S, by virtue of the probability schedule given him, was likely to adopt a given method of responding, shock served to increase his tendency to adopt that method. In the case of the π = .15 groups this trend was observed again, as the differences

between no-shock and shock-wrong groups, while of some size and consistency, were not significant, and the number of Ss who predicted the more frequently occurring event on all of the last 20 trials of Series 1 was small in relation to the number who adopted the same method of responding in the various π = .15 groups. Here S was expected to predict the more frequently occurring event less often than in the π = .05 groups and the shock was expected to have less effect, presumably due to the greater likelihood of S being less able to disregard the less frequently occurring event. With the π = .40 groups there was no effect of shock observed, nor was such an effect expected according to the hypothesis outlined above due to the fact that S would not be able to disregard the less frequently occurring event if, as was assumed, he was attempting to master the problem.

It was noted above that the data of this study could be viewed as the result of an attempt by S to achieve 100 per cent accuracy in a very difficult problem rather than as an automatic or unconditioned learning phenomenon. It is suggested that the view of the Estes theory considers the data of this and similar experiments more from an over-all point of view than has been outlined above. The attempt has been made to sketch this hypothesis from a more analytic and explanatory point of view. What the statistical association theory regards as the outcome of association of stimulus elements on successive trials has been regarded here as the attempt by a human subject to master a very difficult problem, with his final performance dependent on the probability of the occurrence of the alternative events and the consequences

contingent on an incorrect response.

If the interpretation offered above were generalized sufficiently it would take the form of the well-known minimax loss principle of game theory, as it was presented by Edwards (4). In previous discussions of the probability matching phenomenon the prediction that Ss will learn to predict the more frequently occurring event on all trials has been derived from game theory. It is suggested that this interpretation does not take into account the assumptions of game theory which require that S be completely informed and infinitely sensitive. These assumptions are not met in the Estes-type situation. Furthermore, this simple interpretation of strategy does not take into account the initial attitude of S toward his task. When S's initial attitude, as it was hypothesized above, is taken into account, the present hypothesis could be seen as S's response to the Estes situation which minimizes the maximum loss, psychologically, since there were no economic aspects involved. The maximum loss would relate to the tolerance of S to accept error in order to achieve the desired mastery or partial mastery of the problem. To minimize the maximum psychological loss, S would disregard the less frequencly occurring events with increasing ease as the probability of occurrence of those events decreases from .50 to .00.

A hypothesis which makes use of such explanatory concepts as strategy, set, attitude, assumptions, and so forth, violates the letter if not the spirit of the strict stimulus-response relationships specified in the statistical association theory of learning and its accompanying mathematical model. The use of such hypothetical constructs, as

opposed to the intervening variables of the theory may not be justified on the strength of the data of this experiment alone. But, just as there is no parsimony involved in supposing that the attitudes, sets, strategies, and assumptions of human Ss in a situation such as was used in this study affect their performance, neither is there reason to suppose that the attitudes, sets, strategies, and assumptions, which there is every reason to expect do exist in human Ss, do not affect their performance. At any rate the hypothesis proposed above assumes that what was learned by the Ss in this experiment was a new set or attitude toward the problem in the case of the $\pi = .05$ shock-wrong groups and to a lesser degree in the case of the $\pi = .15$ shock-wrong groups.

Since the hypothesis was based on the data of this study and was designed specifically to account for the results of experiments using the Estes-type situation, no attempt will be made to demonstrate the applicability of its predictions to other data. It was offered as an analytical and explanatory hypothesis to provide a basis for further research.

CHAPTER V

SUMMARY AND CONCLUSIONS

The effects of a mild electrical shock on the prediction of uncertain alternative events were studied in this experiment in relation to the statistical association theory of learning and the law of effect. A situation was provided in which human Ss were required to predict which of two alternative events would occur following a ready signal. The final level of responding and the total performance with respect to number of A1 responses and errors were analyzed in terms of the predicted outcomes of the two opposed theories.

Eighty college students were run in an individual modification of the standard verbal conditioning situation used recently by Estes and others. Each trial consisted of a signal light which came on and stayed on until S made a prediction by moving a switch lever to the right or the left as to which of two event lights would come on. For each S one event light was selected as E1 according to a counterbalanced schedule, the other as E2. On the first 120 trials E1 occurred randomly and with the probabilities of .05, .15, and .40 for different groups. On a second series of 80 trials, E1 occurred randomly and with the probability of .20. Ten Ss in each of the probability categories served as experimental groups and were given a mild shock following all incorrect predictions. Ten Ss in each of the probability categories served as control groups and were not shocked on an incorrect prediction. Two additional groups of 10 Ss each were run in the .05 and .15

probability categories and served as control groups to test the effects of the contingency of shock on an incorrect prediction. These Ss were shocked exactly as the Ss in the shock-wrong groups, but without regard to the correctness or incorrectness of the prediction which the shock followed.

Theoretical predictions as to the final number of A1 responses and the asymptotic number of errors were generated from the statistical association theory and were tested against predictions based on the law of effect. The data in general supported the predictions based on the statistical association theory with regard to the final level of A1 responding and the final number of errors. Only in the case of the $\pi = .05$ no-shock and shock-wrong groups on the last 20 trials of Series 2 were the differences between mean number of A1 responses and mean number of errors significant.

Tests of the over-all differences between the no-shock and shock-wrong groups showed that the $\pi = .05$ groups differed significantly, that the $\pi = .15$ groups differed slightly and consistently but not significantly, and that the $\pi = .40$ groups did not differ significantly. This finding led to the development of a hypothesis which suggested that the effects of shock increased as the probability of occurrence of the event predicted decreased from .50 to .00, and that the effects of shock were not sufficiently great to cause the asymptotic performance of the no-shock and shock-wrong groups to differ.

The analysis of the differences between the performances of the shock-wrong and the noncontingent-shock groups indicated that where the

no-shock and shock-wrong groups differed, the difference was the result of the shock following an incorrect prediction rather than the result of the shock alone.

An analysis of the reaction latency failed to reveal any differences between mean reaction latency for the various no-shock and shock-wrong, and shock-wrong and noncontingent-shock groups on the final 10 trials of Series 1 and 2. A more detailed analysis of reaction latencies on A1 and A2 responses also failed to reveal any differences between no-shock and shock-wrong groups.

The following specific conclusions were drawn from the results of the analyses of this experiment:

1. The final learning performance of Ss who predicted the occurrence of uncertain events and who were shocked after an incorrect prediction did not differ from the performances of Ss who were not shocked, with certain exceptions as cited above.

2. Such differences as were observed between no-shock and shock-wrong Ss were the result of the shock following an incorrect prediction and not the result of shock alone.

3. These final learning performances agreed in substance with the predictions derived from the statistical association theory of learning, both with respect to A1 responses and errors, with certain exceptions as noted above.

4. The over-all effects of shock on the performances of the Ss were found to be related to the probability of occurrence of the event predicted. The data suggested that the effects of shock increased as

the probability of the predicted event decreased from .50 to .00.

5. The generality of the statistical association theory of learning could not be extended without some modification to situations such as were used in this study where a risk was involved in the prediction of the uncertain events.

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APPENDIX

TABLE 2

Record of Number of A1 Responses and Errors for Blocks of 20 Trials for the 21 Ss Eliminated Because They Received Uncontrolled Shock Blocks of 20 Trials

	1	2	3	4	5	6	7	8	9	10
					π = .05 shock-wrong group, A1 Responses					
ES1	5	6	4	2	2	0	2	3	3	4
ES2	5	0	0	2	1	0	0	2	0	0
ES3	12	9	9	7	7	6	6	6	4	7
ES4	8	3	2	0	0	1	2	6	2	3
ES5	4	2	0	0	0	0	0	2	0	0
ES6	7	2	1	0	2	0	0	5	1	5
ES7	5	2	0	1	1	1	0	4	5	7
ES8	10	2	0	0	0	0	0	0	4	2
ES9	7	4	2	0	1	0	2	1	4	4
ES10	5	3	1	1	0	1	0	3	1	2
					π = .15 shock-wrong group, A1 Responses					
ES11	8	13	7	8	7	8	3	7	2	4
ES12	13	7	1	5	6	5	4	2	2	0
ES13	5	4	3	2	4	1	0	0	3	2
ES14	6	3	3	3	1	1	0	1	1	6
ES15	5	7	4	10	5	6	5	7	3	8
ES16	7	1	0	3	0	2	3	3	0	4
ES17	10	3	1	2	0	3	3	3	3	2
ES18	11	8	2	5	4	2	0	1	4	1
ES19	12	3	2	2	4	1	2	2	8	2
ES20	11	8	2	3	0	0	0	0	0	1
					π = .40 shock-wrong group, A1 Responses					
ES21	11	3	13	10	6	7	3	5	1	4

TABLE 2 (continued)

	1	2	3	4	5	6	7	8	9	10
		π = .05 shock-wrong group, errors								
ES1	4	7	4	2	3	1	3	7	5	11
ES2	6	0	1	3	3	1	3	7	3	5
ES3	14	9	8	6	8	7	9	8	6	8
ES4	7	4	3	1	0	3	5	9	4	5
ES5	4	3	1	2	0	1	4	6	2	6
ES6	8	3	3	0	3	1	3	9	4	11
ES7	6	2	1	2	3	2	3	8	6	8
ES8	10	2	1	1	1	1	3	2	10	7
ES9	8	5	3	1	1	2	4	8	6	2
ES10	6	4	2	3	0	2	4	7	3	8
		π = .15 shock-wrong group, errors								
ES11	7	13	8	9	7	8	4	9	3	10
ES12	8	8	3	4	9	9	6	7	4	5
ES13	9	5	4	4	5	2	3	2	9	5
ES14	6	4	5	6	4	3	3	6	3	4
ES15	9	8	5	11	5	7	7	9	3	12
ES16	10	3	5	6	2	6	2	7	3	9
ES17	13	4	3	3	2	5	2	8	6	5
ES18	11	9	3	9	9	3	3	3	8	6
ES19	11	4	4	6	7	5	5	9	6	4
ES20	10	9	3	2	2	3	4	4	2	5
		π = .40 shock-wrong group, errors								
ES21	12	5	11	9	10	11	4	7	4	10

TABLE 3

Al Responses and Errors of Two Original, Two Replacement, and Nine Other Original Ss for π = .05 and .15 No-Shock Groups
Blocks of 20 Trials

	1	2	3	4	5	6	7	8	9	10
π = .05, Al Responses										
Original S	14	12	8	9	10	7	9	4	10	9
Replacement S	10	0	2	1	0	0	1	1	4	6
$\bar{X}$ Other Original Ss	6.4	3.3	1.8	1.7	1.1	1.2	1.3	2.3	2.5	3.9
π = .05, Errors										
Original S	12	12	9	10	9	8	10	6	10	10
Replacement S	12	0	3	2	1	1	4	3	8	11
$\bar{X}$ Other Original Ss	7.1	3.8	2.9	2.6	1.8	2.2	4.3	6.4	4.3	7.6
π = .15, Al Responses										
Original S	12	13	11	11	11	6	9	13	7	9
Replacement S	6	3	2	3	2	6	5	3	4	2
$\bar{X}$ Other Original Ss	11.3	6.7	3.9	3.6	3.6	2.9	1.9	3.3	3.4	3.2
π = .15, Errors										
Original S	11	12	9	10	12	8	8	16	5	9
Replacement S	7	4	4	6	5	10	8	8	8	4
Other Original Ss	9.4	7.9	5.0	5.9	6.1	5.4	4.7	6.6	5.2	6.3

TABLE 4

Analysis of Variance of Al Responses on Trials 1 Through 200 Taken in Blocks of 20

Source	df	Mean Square	F
	π = .05 No-Shock and Shock-Wrong Groups		
Between Ss	19		
Shock	1	67.28	6.37*[1] (5.14*)[2]
Error (b)	18	10.65	
Within Ss	180		
Trials	9	50.22	18.67*** (16.51***)
Shock X Trials	9	1.65	0.61 (0.43)
Error (w)	162	2.69	

TABLE 5

Analysis of Variance of Al Responses on Trials 1 Through 200 Taken in Blocks of 20

Source	df	Mean Square	F
	π = .15 No-Shock and Shock-Wrong Groups		
Between Ss	19		
Shock	1	34.45	2.18 (3.42)
Error (b)	18	15.83	
Within Ss	180		
Trials	9	108.33	28.21*** (28.95***)
Shock X Trials	9	1.98	0.52 (0.51)
Error (w)	162	3.84	

[1] * indicates significant at the .05 level, ** indicates significant at the .01 level, and *** indicates significant at the .001 level.

[2] Values in parentheses are those obtained with the two original Ss included in the data.

TABLE 6

Analysis of Variance of Al Responses on Trials 1 Through 200 Taken in Blocks of 20

Source	df	Mean Square	F
	π = .40 No-Shock and Shock-Wrong Groups		
Between Ss	19		
Shock	1	1.81	0.06
Error (b)	18	27.87	
Within Ss	180		
Trials	9	64.31	10.77***
Shock X Trials	9	6.35	1.06
Error (w)	162	5.97	

TABLE 7

Results of t Tests of Differences Between Mean Number of Al Responses on Last 20 Trials of Series 1

		No-Shock	Shock-Wrong	t NS vs. SW
		No-Shock and Shock-Wrong Groups		
π = .05	$\bar{X}$	1.10	0.30	1.15(1.95)
	s^2	2.54	0.23	
π = .15	$\bar{X}$	3.20	2.20	1.03
	s^2	6.84	2.62	
π = .40	$\bar{X}$	7.50	8.80	1.09
	s^2	8.50	5.51	

TABLE 8

Results of t Tests of Differences Between Mean Number of A1 Responses on Last 20 Trials of Series 2

		No-Shock	Shock-Wrong	t NS vs. SW
		No-Shock and Shock-Wrong Groups		
$\pi = .05$	$\bar{X}$	4.10	1.60	2.43 *(2.44 *)
	s^2	8.77	1.82	
$\pi = .15$	$\bar{X}$	3.10	3.20	0.58(0.51)
	s^2	6.54	4.18	
$\pi = .40$	$\bar{X}$	6.20	5.10	0.93
	s^2	10.40	3.66	

TABLE 9

Analysis of Variance of A1 Responses for the Last 20 Trials of Series 2

Source	df	Mean Square	F
Shock	1	20.42	3.47 (4.97*)
π Value	2	47.27	8.03 **(5.84**)
Shock X π Value	2	8.47	1.44 (0.99)
Error	54	5.89	

TABLE 10

Analysis of Variance of Errors on Trials 1 Through 200 Taken in Blocks of 20

Source	df	Mean Square	F
	π = .05 No-Shock and Shock-Wrong Groups		
Between Ss	19		
Shock	1	53.05	8.64**
Error (b)	18	6.14	
Within Ss	180		
Trials	9	82.89	21.53 ***
Shock X Trials	9	1.78	0.46
Error (w)	162	3.85	

TABLE 11

Analysis of Variance of Errors on Trials 1 Through 200 Taken in Blocks of 20

Source	df	Mean Square	F
	π = .15 No-Shock and Shock-Wrong Groups		
Between Ss	19		
Shock	1	28.13	4.16
Error (b)	18	6.76	
Within Ss	180		
Trials	9	37.18	7.99 **
Shock X Trials	9	1.21	0.26
Error (w)	162	4.66	

TABLE 12

Over-all Analysis of Variance of Errors on Trials 1 Through 200 Taken in Blocks of 20

Source	df	Mean Square	F
	π = .40 No-Shock and Shock-Wrong Groups		
Between Ss	19		
Shock	1	0.32	0.04
Error (b)	18	7.21	
Within Ss	180		
Trials	9	23.18	3.80
Shock X Trials	9	3.89	0.64
Error (w)	162	6.10	

TABLE 13

Results of t Tests of Differences Between Mean Number of Errors on Last 20 Trials of Series 1

		No-Shock	Shock-Wrong	t, NS vs. SW
		No-Shock and Shock-Wrong Groups		
π = .05	$\bar{X}$	2.10	1.50	0.82
	s^2	2.54	0.28	
π = .15	$\bar{X}$	5.90	4.40	1.56
	s^2	7.88	2.04	
π = .40	$\bar{X}$	9.40	9.00	0.34
	s^2	6.71	0.71	

TABLE 14

Results of *t* Tests of Differences Between Mean Number of Errors on Last 20 Trials of Series 2

		No-Shock	Shock-Wrong	*t*, NS *vs.* SW
		No-Shock and Shock-Wrong Groups		
$\pi = .05$	$\bar{X}$	7.90	5.50	2.12*
	s^2	7.55	5.17	
$\pi = .15$	$\bar{X}$	6.10	6.00	0.09
	s^2	3.88	7.33	
$\pi = .40$	$\bar{X}$	8.50	7.60	0.89
	s^2	8.50	1.82	

TABLE 15

Analysis of Variance of Errors for the Last 20 Trials of Series 2

Source	df	Mean Square	F
Shock	1	19.27	3.36
π Value	2	20.82	3.63 *
Shock X π Value	2	6.82	1.19
Error	54	5.73	

TABLE 16

Analysis of Variance of Al Responses on Trials 1 Through 200 Taken in Blocks of 20

Source	df	Mean Square	F
π = .05 Shock-Wrong and Noncontingent-Shock Groups			
Between Ss	19		
Shock	1	126.41	11.15 **
Error (b)	18	11.34	
Within Ss	180		
Trials	9	43.46	8.74 ***
Shock X Trials	9	4.97	2.05 *
Error (w)	162	2.43	

TABLE 17

Over-all Analysis of Variance of Al Responses on Trials 1 Through 200 Taken in Blocks of 20

Source	df	Mean Square	F
π = .15 Shock-Wrong and Noncontingent-Shock Groups			
Between Ss	19		
Shock	1	0.41	0.03
Error (b)	18	11.75	
Within Ss	180		
Trials	9	102.21	24.75 ***
Shock X Trials	9	2.07	0.50
Error (w)	162	4.13	

TABLE 18

Results of the t Tests of the Differences Between Mean Al Response and Error Scores for the Last 20 Trials of Series 1 and 2

	Trials 101-120	Trials 181-200
	Shock-Wrong and Noncontingent-Shock Groups	
π = .05, Al Responses	t = 1.46	3.47 **
π = .05, Errors	1.25	3.66 **
π = .15, Al Responses	0.30	0.65
π = .15, Errors	0.30	0.40

TABLE 19

Results of t Tests of the Differences Between Mean Reaction Latency on the Last 10 Trials of Series 1

	No-Shock vs. Shock-Wrong	Shock-Wrong vs. Noncontingent-Shock
	All Groups	
π = .05	t = 0.01	0.68
π = .15	1.30	1.05
π = .40	0.33	

TABLE 20

Results of t Tests of the Differences Between Mean Reaction Latency on the Last 10 Trials of Series 2

	No-Shock vs. Shock-Wrong	Shock-Wrong vs. Noncontingent-Shock
	All Groups	
$\pi = .05$	$t = 0.56$	0.53
$\pi = .15$	0.26	1.28
$\pi = .40$	0.08	

TABLE 21

Results of t Tests of the Differences Between Mean Reaction Latency on the Last A1 Response and the Immediately Previous A2 Response

	No-Shock	Shock-Wrong	Noncontingent-Shock
	All Groups		
$\pi = .05$	$t = 0.03$	0.16	0.06
$\pi = .15$	0.00	0.22	0.15
$\pi = .40$	0.07	0.05	

TABLE 22

Results of *t* Tests of the Differences Between Mean Number of Al Responses on the Four Practice Trials and First Trial

	No-Shock vs. Shock-Wrong	Shock-Wrong vs. Noncontingent-Shock
	All Groups	
$\pi = .05$	$t = 0.52$	1.40
$\pi = .15$	1.64	0.00
$\pi = .40$	0.97	

TABLE 23

Record of the Number of Al Responses for Blocks of 20 Trials for All Ss
Blocks of 20 Trials

	1	2	3	4	5	6	7	8	9	10
				π = .05, No-Shock						
S1	6	4	4	3	1	1	1	3	1	8
S2	3	2	0	0	0	0	0	1	0	1
S3	10	7	3	4	2	2	1	0	7	7
S4	10	0	1	0	1	0	1	0	3	4
S5	4	1	0	1	0	0	0	2	1	0
S6	6	3	1	3	1	2	1	4	2	8
S7	9	5	5	3	4	5	0	1	3	2
S8	10	0	1	2	0	0	1	1	4	6
S9	7	4	2	0	1	1	7	5	5	2
S10	3	4	0	1	0	0	1	5	1	3
				π = .15, No-Shock						
S11	12	4	5	3	3	5	3	3	3	9
S12	12	11	5	8	10	8	5	4	7	5
S13	9	9	3	1	4	1	2	1	4	1
S14	10	6	3	4	5	3	3	6	5	1
S15	13	7	2	3	1	3	1	5	3	2
S16	11	6	5	5	2	0	1	5	0	5
S17	11	6	5	2	0	0	1	3	2	1
S18	12	7	5	3	4	2	1	1	5	3
S19	6	3	2	3	2	6	5	3	4	2
S20	12	4	2	3	3	4	0	2	2	2
				π = .40, No-Shock						
S21	12	9	10	12	10	9	8	10	9	8
S22	12	8	7	8	7	10	10	7	7	5
S23	10	14	14	16	15	3	8	3	6	8
S24	8	16	2	5	9	7	4	11	12	0
S25	14	11	10	11	12	12	13	9	7	6
S26	10	5	8	9	10	9	4	3	0	4
S27	12	11	11	13	13	6	12	6	8	8
S28	8	11	7	5	7	3	2	1	2	3
S29	10	11	12	11	11	9	10	13	12	10
S30	12	10	7	12	12	7	7	15	9	10

TABLE 23 (Continued)

	1	2	3	4	5	6	7	8	9	10
				π = .05, Shock-Wrong						
S31	3	1	1	0	0	1	0	2	0	1
S32	4	3	2	1	0	0	0	4	0	3
S33	5	0	0	0	0	0	0	0	1	0
S34	7	1	0	0	1	0	3	2	7	3
S35	1	1	0	1	1	1	0	0	2	1
S36	5	1	1	0	0	0	0	3	2	4
S37	3	2	0	0	0	0	0	1	0	1
S38	12	5	0	5	0	1	1	0	5	1
S39	8	1	1	1	1	0	1	0	2	2
S40	3	2	0	0	0	0	1	0	0	0
				π = .15, Shock-Wrong						
S41	9	5	6	3	7	4	4	8	1	7
S42	5	0	2	6	0	0	0	1	1	1
S43	9	7	2	3	5	4	0	1	2	2
S44	4	5	0	1	0	0	1	0	2	1
S45	14	3	0	1	1	1	2	1	3	2
S46	9	6	5	2	1	3	1	2	2	6
S47	10	8	4	2	7	3	1	2	3	4
S48	10	12	9	2	6	1	0	0	3	2
S49	7	3	3	3	3	4	4	3	6	3
S50	10	8	1	4	3	2	1	2	0	4
				π = .40, Shock-Wrong						
S51	13	7	10	10	11	8	6	8	4	3
S52	12	12	9	12	12	8	8	7	4	4
S53	11	10	10	12	8	6	8	6	11	7
S54	10	8	12	10	13	6	8	4	7	8
S55	14	10	13	10	7	13	13	9	8	7
S56	10	4	7	7	7	7	5	6	5	4
S57	12	12	8	13	9	10	6	5	3	4
S58	12	9	8	9	10	11	6	5	3	4
S59	10	9	11	14	9	8	7	6	7	3
S60	10	9	14	13	7	11	9	12	12	7

TABLE 23 (Continued)

	1	2	3	4	5	6	7	8	9	10
			π= .05, Noncontingent-Shock							
S61	3	0	0	0	0	0	2	4	0	3
S62	4	2	1	0	0	1	1	1	2	2
S63	7	4	3	2	4	3	1	3	8	4
S64	6	3	4	0	2	0	5	6	5	5
S65	4	3	1	3	1	0	2	8	4	3
S66	8	2	5	0	2	0	1	4	2	9
S67	1	2	0	0	0	1	0	4	2	4
S68	8	4	1	1	3	3	7	6	9	5
S69	9	3	1	0	2	0	2	7	5	3
S70	9	3	3	7	3	1	3	5	5	4
			π= .15, Noncontingent-Shock							
S71	8	3	3	4	4	3	3	1	2	1
S72	12	9	1	3	2	5	3	2	1	1
S73	8	6	2	2	2	1	2	0	0	1
S74	10	3	1	4	2	2	3	3	2	3
S75	11	6	3	2	1	2	1	1	0	1
S76	7	8	6	7	3	3	0	2	0	6
S77	9	7	5	2	4	4	1	1	2	2
S78	11	9	8	10	6	1	2	0	5	4
S79	3	2	4	4	3	1	3	3	4	6
S80	11	11	3	0	0	2	2	0	2	1

TABLE 24

Record of the Number of Errors for Blocks of 20 Trials for All Ss
Blocks of 20 Trials

	1	2	3	4	5	6	7	8	9	10
				π = .05, No-Shock						
S1	7	5	6	3	1	2	4	5	3	11
S2	4	2	1	1	2	1	3	6	2	6
S3	10	7	4	5	3	3	2	2	7	8
S4	11	1	1	1	1	2	4	7	5	5
S5	5	2	1	2	0	1	4	6	3	6
S6	7	4	3	3	2	1	4	5	5	12
S7	10	5	6	4	6	6	3	6	6	7
S8	12	0	3	2	1	1	4	3	8	11
S9	6	3	3	1	1	3	10	12	7	4
S10	4	5	1	3	0	1	5	9	1	9
				π = .15, No-Shock						
S11	11	6	5	6	5	7	4	7	4	7
S12	9	12	7	7	9	10	8	9	6	8
S13	10	10	4	5	9	2	5	3	8	6
S14	9	7	5	5	8	7	6	11	5	3
S15	8	8	3	8	3	6	5	5	3	6
S16	6	8	7	8	4	4	4	7	3	9
S17	12	7	5	5	3	4	4	8	5	4
S18	10	8	6	3	9	3	2	3	9	6
S19	7	4	4	6	5	10	8	8	8	4
S20	10	5	3	6	5	6	4	6	4	8
				π = .40, No-Shock						
S21	11	9	12	11	9	9	9	8	8	10
S22	14	8	12	11	13	10	11	8	8	8
S23	12	11	9	7	13	4	10	5	8	11
S24	9	13	5	11	7	11	6	12	12	2
S25	10	10	7	11	10	12	15	7	9	6
S26	11	7	8	10	10	12	5	5	3	8
S27	8	13	12	6	10	10	9	11	7	9
S28	10	10	12	10	9	6	5	1	6	8
S29	7	9	7	5	11	11	7	8	10	12
S30	10	9	10	14	8	9	9	13	9	11

TABLE 24 (Continued)

	1	2	3	4	5	6	7	8	9	10
				π = .05, Shock-Wrong						
S31	4	2	3	0	1	2	3	6	3	7
S32	5	3	3	2	2	1	3	5	3	3
S33	7	0	1	1	1	1	3	2	7	5
S34	6	2	1	1	1	2	6	9	7	5
S35	2	2	1	3	1	2	4	4	4	7
S36	6	2	3	0	1	1	3	5	3	10
S37	4	2	1	1	2	1	3	6	3	6
S38	14	5	1	4	1	2	4	2	7	4
S39	9	2	2	2	1	2	4	7	4	2
S40	4	3	1	2	0	1	5	4	2	6
				π = .15, Shock-Wrong						
S41	12	7	4	2	5	4	5	12	2	11
S42	8	1	2	7	3	4	3	6	4	4
S43	13	8	3	7	6	5	3	3	6	7
S44	5	4	2	6	3	4	4	7	6	3
S45	10	4	1	6	3	4	6	5	5	6
S46	10	8	7	5	3	5	4	6	5	8
S47	8	7	6	5	9	7	4	7	2	7
S48	10	11	8	6	9	2	3	2	7	3
S49	6	4	5	4	4	6	5	10	8	3
S50	8	7	2	7	4	3	5	6	2	8
				π = .40, Shock-Wrong						
S51	10	9	12	9	11	8	7	4	3	7
S52	10	12	6	13	12	8	9	8	5	7
S53	11	13	9	13	10	5	7	6	15	8
S54	9	8	7	10	7	10	9	9	5	8
S55	10	9	14	12	9	11	11	11	8	9
S56	11	8	9	12	11	5	8	6	6	9
S57	8	12	11	12	11	12	7	8	6	5
S58	14	7	10	11	11	9	10	8	9	8
S59	13	9	11	9	8	13	7	12	5	6
S60	10	6	11	17	11	9	7	8	14	9

TABLE 24 (Continued)

	1	2	3	4	5	6	7	8	9	10
				π = .05, Noncontingent-Shock						
S61	4	1	2	0	1	1	3	8	3	9
S62	5	2	0	1	2	2	4	6	5	5
S63	7	4	4	3	3	2	4	3	8	7
S64	7	2	5	1	2	2	6	9	5	5
S65	5	4	2	5	1	1	6	12	4	9
S66	9	3	5	0	3	1	2	8	5	9
S67	2	2	1	1	2	2	3	7	5	5
S68	10	4	2	2	4	4	8	8	9	8
S69	10	4	2	1	2	2	5	10	5	5
S70	10	4	4	7	3	2	7	7	7	6
				π = .15, Noncontingent-Shock						
S71	11	5	5	5	4	5	4	5	5	7
S72	7	10	3	4	5	7	4	7	4	4
S73	8	5	3	6	7	2	5	2	6	6
S74	11	2	3	7	5	4	6	6	6	5
S75	9	7	4	7	3	5	5	5	2	7
S76	8	8	4	8	4	5	3	6	3	10
S77	4	8	5	3	7	6	4	6	5	5
S78	9	8	9	12	5	2	5	2	9	7
S79	4	5	6	5	6	5	6	10	8	6
S80	7	10	4	5	2	5	6	4	2	7

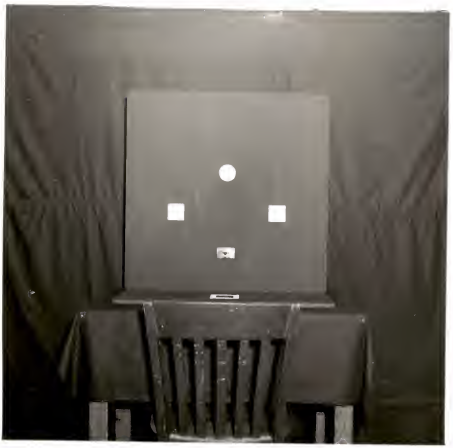


Fig. 7. Photograph of the stimulus panel.

BIOGRAPHICAL SKETCH

Edward E. Eddowes was born March 29, 1930, in Philadelphia, Pennsylvania. He was graduated from Central High School of Philadelphia in June, 1947. He attended Duke University for two years before joining the United States Navy as a Naval Aviation Cadet. Upon successful completion of the Navy flight training program, he received a commission in the Naval Reserve and was appointed a Naval Aviator. He was honorably discharged from the Navy in October, 1953. In February, 1954 he enrolled at the University of Miami, Florida, from which institution he received his Bachelor of Arts degree in February, 1956, with a major in journalism and a minor in psychology. He entered the graduate training program in psychology at the University of Florida in September, 1956. He received his Master of Arts degree in psychology at the University of Florida in February, 1958.

This dissertation was prepared under the direction of the Chairman of the candidate's Supervisory Committee and has been approved by all members of the Committee. It was submitted to the Dean of the College of Arts and Sciences and to the Graduate Council and was approved as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

August 8, 1959

Dean, College of Arts and Sciences

Dean, Graduate School

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